# Geometry Notes

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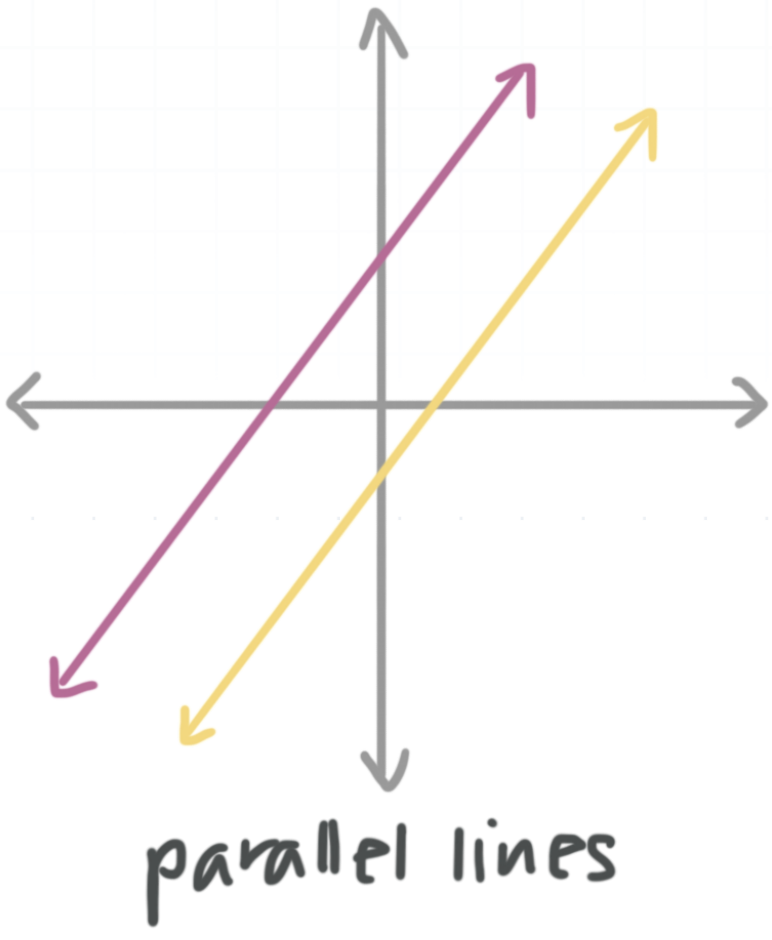
MATH

# Lines, parallel, perpendicular, or neither

In this lesson we'll look at how to use the slope between two points on a line to see if the lines are perpendicular, parallel, or neither.

## Parallel lines

Parallel lines have the same slope. In two-dimensional geometry they do not intersect one another and they are always the same distance apart.




## Perpendicular lines

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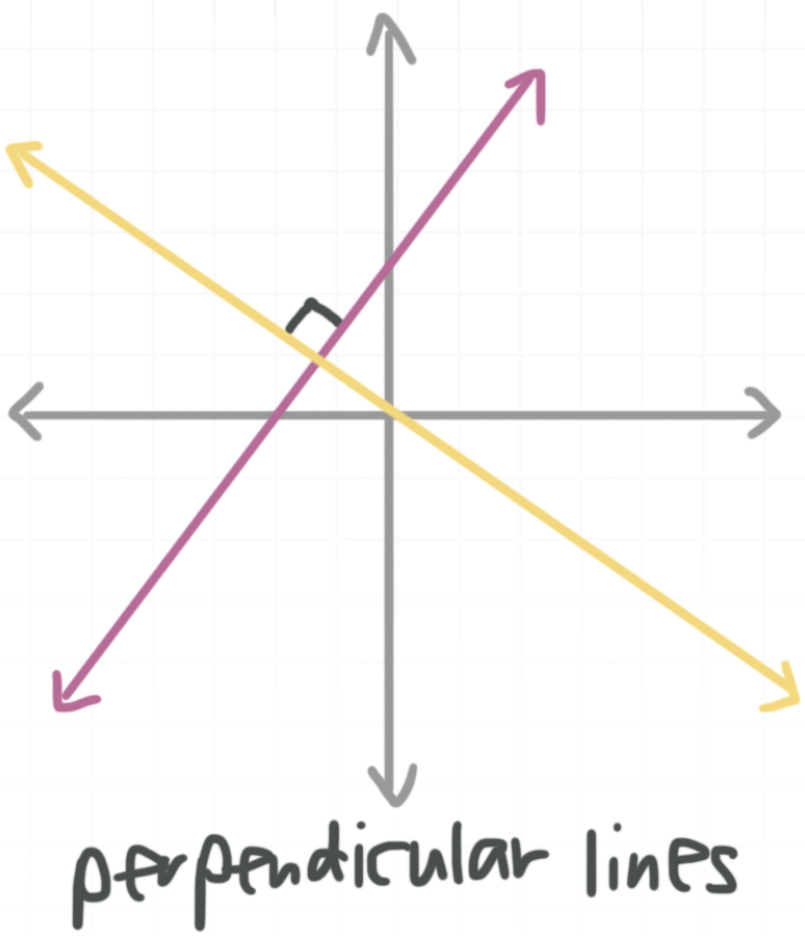
Perpendicular lines have opposite reciprocal slopes and they intersect to form $90^\circ$ angles.




Let's do a few examples.

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**Example**

Each pair of points in the table below are points that lie on the given line. Which lines are parallel to each other and which lines are perpendicular?

| Line | Point 1 | Point 2 |
|---|---|---|
| Line AB | (3,1) | (-3,11) |
| Line CD | (0,2) | (5,5) |
| Line EF | (-5,-5) | (0,-2) |

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Use the slope formula for each line.

Slope of line $\overleftrightarrow{AB}$: $$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{11 - 1}{-3 - 3} = \frac{10}{-6} = -\frac{5}{3}$$

Slope of line $\overleftrightarrow{CD}$: $$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{5 - 2}{5 - 3} = \frac{3}{5}$$

Slope of line $\overleftrightarrow{EF}$: $$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-2 - (-5)}{0 - (-5)} = \frac{-2 + 5}{0 + 5} = \frac{3}{5}$$

Lines $\overleftrightarrow{CD}$ and $\overleftrightarrow{EF}$ have the same slope, $3/5$, so these two lines are parallel. Lines $\overleftrightarrow{AB}$ and $\overleftrightarrow{CD}$ have opposite reciprocal slopes so the lines are perpendicular. Lines $\overleftrightarrow{EF}$ and $\overleftrightarrow{AB}$ are also perpendicular for the same reason.

Let's see how we can find the slope of a parallel line.

**Example**

What is the slope of a line parallel to $\overleftrightarrow{CD}$, if $\overleftrightarrow{CD}$ passes through the points, $(4,5)$ and $(-2,8)$?

Parallel lines have the same slope, so first we need to find the slope of $\overleftrightarrow{CD}$. Use the slope formula.

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{8 - 5}{-2 - 4} = \frac{3}{-6} = -\frac{1}{2}$$

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Any line parallel to $\overleftrightarrow{CD}$ will have a slope of $-1/2$.

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Now let's look at how to find a perpendicular slope.

**Example**

What is the slope of a line perpendicular to $\overleftrightarrow{WX}$, if $\overleftrightarrow{WX}$ passes through the points $(-3,5)$ and $(2,-6)$?

Perpendicular lines have opposite reciprocal slopes, so first we need to find the slope of $\overleftrightarrow{WX}$. Use the slope formula.

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-6-5}{2-(-3)} = \frac{-11}{5} = -\frac{11}{5}$$

Now we find the opposite reciprocal by flipping the fraction and multiplying by $-1$ to get $5/11$. The slope of a line perpendicular to $\overleftrightarrow{WX}$ is $5/11$.

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